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Distribution Patterns of Latex Sucrose Content and Concurrent Metabolic Activity at the Trunk Level with Different Tapping Systems and in Latex Production Bark of *Hevea brasiliensis*

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ABSTRACT

Distribution patterns of latex sucrose content and concurrent metabolic activity at the trunk level with different tapping systems, namely 1/2S d/2 (a half spiral cut alternate daily), 1/2S d/3 ET 2.5%.8/y (a half spiral cut one day in tapping followed by two days of rest, stimulated with ethephon, eight applications per year) and DCA (Double Cut Alternate, 2×1/2S d/4 (t,t), two half spiral cuts, each cut tapped alternate on every four days) were studied. RRIM600 rubber trees were used to map the latex metabolic status from different heights on both panel A and panel B. Latex was collected by puncturing trunks at various positions and was analyzed using Latex Diagnosis technique (LD). The concurrent comparison of latex sucrose and inorganic phosphorus concentrations for every sampling position allowed estimating the size and shape of the actual latex regeneration area. Regular tapping induced latex sucrose depletion in tapped panel bark. This sucrose depletion was enhanced by the use of DCA, as a consequence of increased production and therefore higher latex regeneration metabolism. DCA also induced a huge sucrose sink effect above tapped cut on both panel A and panel B and outside the metabolically active area.

Key words: *Hevea brasiliensis*, distribution pattern, latex, sucrose content, metabolic activity, tapping systems

INTRODUCTION

In Thailand, the rubber tree (*Hevea brasiliensis* Muell. Arg.) is regarded as one of the major economic crops, as it directly or indirectly supports rubber farmers. Concerning economic value, not only latex production, but also wood timber brings a significant income to the farmers. Both rubber production and growth require assimilates from photosynthesis, mainly in the form of sucrose. As farmers' benefit relies on suitable management in order to keep the balance between rubber production and plant growth, it is worth understanding the influence of regular tapping on the growth of the tree. As a matter of fact, a negative relationship exists between latex

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production and wood biomass creation (Templeton, 1969; Wycherley, 1976; Sethuraj, 1985; Gohet, 1996; Gohet *et al*., 1996).

Lustinec and Resing (1965) found, using radio-labeled isotopes, that the flow area of a recently opened rubber tree was distributed about 40-50 cm above and below the tapping cut. On the older trees, this area could extend up to 70 cm above the cut and to the whole area below the tapping cut. Buttery and Boatman (1966), using turgor pressure measurements to determine drained area, reported a pressure drop down to 1.20 m below the tapping cut. Pakianathan *et al.* (1975) termed a bark area where rapid movement of latex near the region of the tapping cut could occur "a potential displacement area". Tupy (1973a) showed that sucrose latex content was depleted below and above the tapping cut as a consequence of latex regeneration process. Nevertheless, none of these works concurrently described the sucrose supply/utilization balance and the associated latex metabolic activity at the trunk level. Silpi *et al.* (2001) applied the Latex Diagnosis technique (Eschbach *et al*., 1984; Jacob *et al*., 1985, 1988a, 1988b, 1995) and reported that the location of the latex regeneration bark area mostly on tapped panel (A) was distributed 40 cm below and above the tapping cut. The basal level of the panel B (untapped panel) seems to confirm that the concurrent increase in metabolic activity is caused by latex regeneration.

The aim of this study was to describe, and also quantify, the sucrose balance between supply and utilization in the latex producing bark of the rubber tree, as well as the concurrent latex metabolic activity. Such a study could not be restricted to only the tapped panel, as some other bark areas might also be involved or at least affected by the latex regeneration process. Physiological analyses were, therefore, carried out on the untapped bark area as well, in order to map the latex metabolic activity and the concurrent latex sucrose availability at the trunk level. Tapping systems were used as a tool to study the influence of an increased rubber production, and therefore an enhanced latex regeneration process, on these metabolic characteristics of the latex sink.

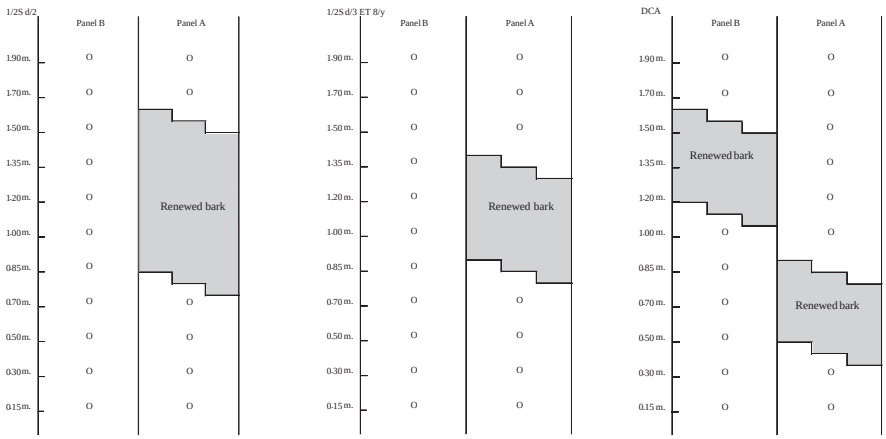
MATERIALS AND METHODS

The measurements and analyses were performed in September 2003, using RRIM600 clone, planted in Chachoengsao Rubber Research Center (CRRC) in 1992 and opened for tapping in May 2000. The tapping systems used were 1/2S d/2 (a half spiral cut alternate daily), 1/2S d/3 ET 2.5%.8/y (a half spiral cut one day in tapping followed by two days of rest, stimulated with ethephon, eight applications per year) and DCA (Double Cut Alternate, 2×1/2S d/4 (t,t) ET2.5% 2×4/y(8/y), two half spiral cuts, each cut tapped alternatly every four days, stimulated with ethephon, four applications per panel or eight applications per year). In each treatment, four sampled trees were chosen as representing homogeneous rubber production (quantity and dynamics) and girth compared to the average of each treatment.

Sampling positions for panel A and panel B were prepared by dragging parallel lines above and below in accordance to the tapping cut. The distance between two successive lines was 15 cm from ground level to 2.0 m high. One sampling point was placed in each line (Figure 1).

Latex collection was performed in the morning, from 6.00 to 7.00 am on each tapping day. An iron punch (1 mm diameter, 2 cm long) was punched into the bark until reaching the wood. Puncture was followed by the insertion of a polyethylene tube into the hole in order to collect latex in a sampling hemolysis tube. Sampling was performed upwards from the basal level to 2.0 m level from ground, first on panel A then on panel B (Figure 1).

On each tree, ten latex drops were collected from each sampling position to measure



1a 1b 1c

Figure 1 Positions of the 36 latex samplings performed on each tree. (1a) 1/2S d/2 (1b) 1/2S d/3.ET 2.5%.8/y (1c) DCA (2x1/2S d/4(t,t) ET2.5% 2x4/y(8/y)).

latex sucrose (Suc), inorganic phosphorus (Pi), reduced thiols (R-SH) and dry rubber content (DRC) using latex diagnosis (LD) technique (Jacob *et al*., 1995) adapted to the CRRC Latex Diagnosis Laboratory facilities (Gohet and Chantuma, 1999). Only the results concerning inorganic phosphorus (Pi, indicator of latex metabolic activity) and sucrose (Suc, precursor molecule of the latex rubber synthesis) were presented and discussed hereafter. The concentrations measured for these two major physiological parameters were expressed in millimols per liter of fresh latex (mM.l^{-1}).

RESULTS AND DISCUSSION

1. Effect of tapping systems on latex metabolic activity, described by inorganic phosphorus content (Pi)

1.1 Effect of tapping systems on latex inorganic phosphorus concentrations

The latex metabolic status within the trunk bark was evaluated by comparing inorganic phosphorus (Pi, mM.l^{-1}) values measured in each sampling position (Figure 2). The average Pi values were 19.7 mM.l^{-1}, 12.3 mM.l^{-1} and 10.1 mM.l^{-1} on DCA system, 1/2S d/3 ET 2.5%.8/y and control (1/2S d/2), respectively. As this Pi value was considered a good indicator of latex metabolic activity, which confirmed that DCA enhanced the latex metabolic activation inside the trunk as a whole (Figure 2).

On 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y, no significant latex metabolic activity was observed on tapped panel (BO-1 or panel A) compared to that observed on the untapped panel (BO-2 or panel B). On DCA trees, the metabolism enhanced in tapped panel A (at 0.80 m from ground) and tapped panel B (1.50 m from ground) as Pi value varied from 14.6 to 25.0 mM.l^{-1} (mean 19.7 mM.l^{-1}), whereas on 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y trees the metabolism was lower, as Pi value varied in the range from 5.7 to 15.5 mM.l^{-1} (mean 10.1 mM.l^{-1}) and from 7.7 to 21.3 mM.l^{-1}(mean 12.3 mM.l^{-1}), respectively. Therefore, DCA significantly increased the size of this latex metabolically active area in both panel A and panel B (Figure 2).

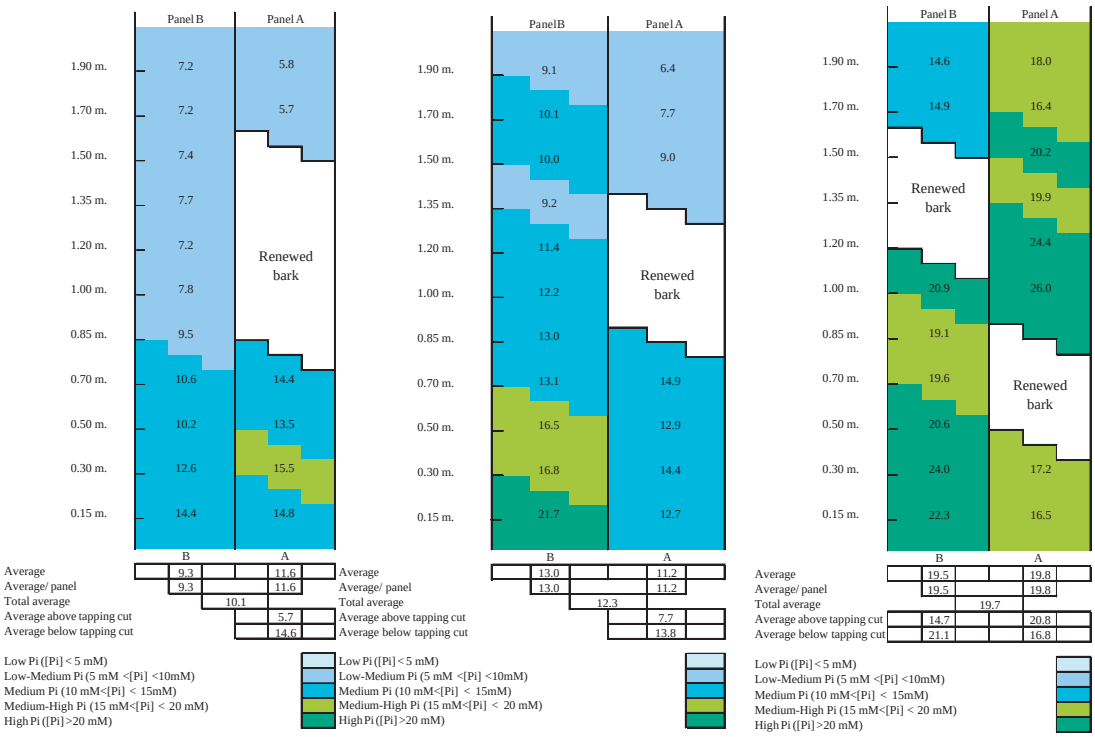


Figure 2 Latex metabolic activity areas determined by latex Pi level (Average of 4 replications per treatment) (2a) 1/2S d/2, (2b) 1/2S d/3.ET 2.5%.8/y and (2c) DCA system.

1.2 Distribution of latex metabolic activity (Pi) along the trunk and comparison of tapped panels (A and B) for different tapping systems

The vertical distribution of the latex metabolic activity, estimated by latex Pi content, for each panel (panel A and panel B) and for tapping systems treatments as shown in Figure 3. On panel A, the Pi level of all treatments (1/2S d/2, 1/2S d/3 ET 2.5%.8/y and DCA) was quite constant from 60 cm below the tapping cut (12 to17 mM.l^{-1}) but above the tapping cut DCA system increased Pi level more than 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y (Figure 3).

On panel B, 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y were not tapped and showed Pi level less than DCA system. In contrast, DCA was tapped both on panel A and B, thus DCA increased metabolic activity both below and above the tapping cut and increased the size of this latex metabolically active area (Figure 3).

Despite the Pi values always being higher on DCA than on 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y, the same downward increasing gradient was observed on all treatments. The Pi values regularly decreased with higher sampling position. In the same previous work (Silpi *et al.*, 2001), the Pi level was quite constant from 40 cm above the tapping cut down to 50 cm below the tapping cut (6 to 7 mM.l^{-1}), but increased significantly and regularly when sampling was performed at the bottom of the panel.

2. Effect of tapping systems on latex sucrose content

2.1 Effect of tapping systems on latex sucrose concentrations

The sucrose contents on panel A were 13.5 mM.l^{-1}, 11.5 mM.l^{-1} and 5.5 mM.l^{-1} on 1/2S d/2, 1/2S d/3 ET 2.5%.8/y and DCA system

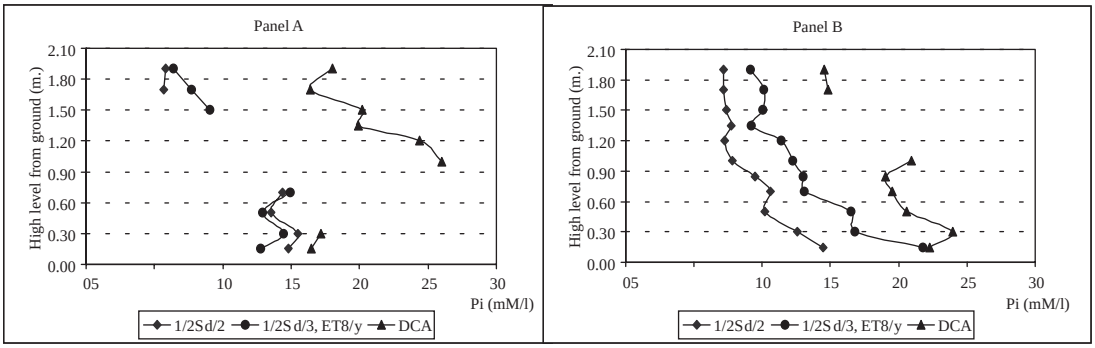


Figure 3 Average Pi level depending on distance from ground on panel A and panel B.

respectively (Figure 4). In the area located below the cut of tapped panel B (high cut) of DCA system, the sucrose content of 12.1 mM/ml was not significantly different compared with other tapping systems. This depletion of latex sucrose content near the tapping cut was confirmed by the previous works (Tupy,1973a and b) and logically described the intensity of sucrose consumption required for the latex regeneration process as a consequence of regular tapping.

These average concentrations were negatively correlated with the estimated sizes of their respective latex regeneration areas, as well as with the average latex metabolic activity (Pi) and the rubber productions since the start of the experiment (May 2000 – February 2004) observed on the concerned trees (Table 1). The total area with both a low latex sugar content and a high latex metabolic activity (high Pi level) could, therefore, be considered as the bark area where latex regeneration actually took place and thus could easily be identified using the latex diagnosis technique. It was thus possible to estimate quite precisely its size and its shape. The extension of this latex regeneration area (low latex sucrose + high latex Pi) could be estimated at about 0.29 m^2, 0.32 m^2 and 0.42 m^2 on 1/2S d/2, 1/2S d/3 ET 2.5% .8/y and DCA system respectively, which included the involved areas above and below the tapping cut both on panel A and panel B.

The average latex sucrose content in tapped panel A and B was higher in DCA (13.3 $mM.l^{-1}$) than in the other treatments (12.6 –12.7 $mM.l^{-1}$) (Figure 4). This reflected a higher latex regeneration activity, and therefore a higher sucrose consumption for rubber synthesis inside DCA. Gohet and Chantuma (2003) reported that the competition between the two DCA tapping cuts for latex carbohydrate supply remained quite low. Low cut (panel A) induced the metabolic activity inside the area located below the cut of both tapped panel A and B. Also, high cut (panel B) enhanced sugar translocation in phloem, which was inside the area located above the cut of both tapped panels. Thus DCA system could enlarge the ability of sink.

2.2 Latex sucrose distribution along the trunk

The enhancement of the metabolic activity on panel A induced by the use of tapping systems were confirmed by lower sucrose content below the cut of tapped panel. However, depletion of sucrose content on 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y was lower than DCA system. The sucrose content followed the same trend for all treatments: sucrose was minimal near the tapping cut and then increased downward as the regeneration process seemed less and less important (Silpi *et al.*, 2001) (Figure 4). Sucrose contents on above the cut of the tapped panel of all tapping systems were similar.

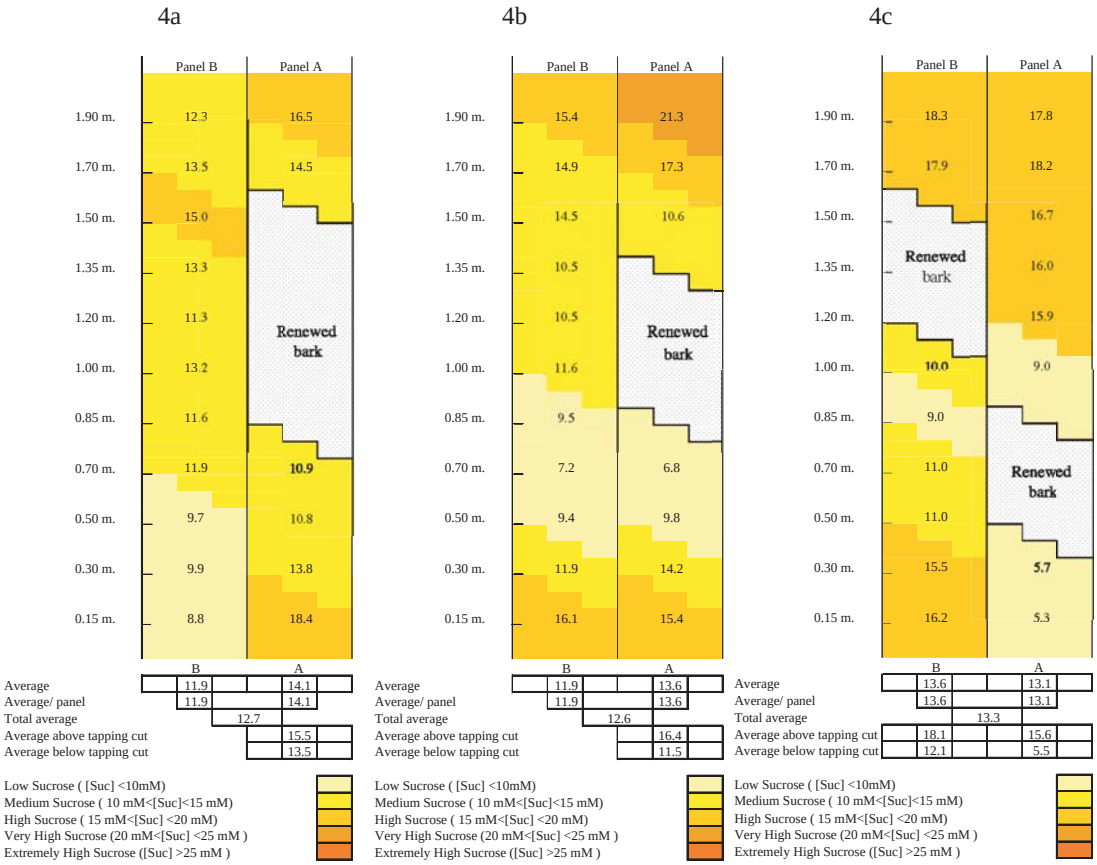


Figure 4 Latex sucrose content distribution in the lower part of the trunk (average of 4 replications per treatment). The estimated latex regeneration area was limited by low Sucrose and high Pi. (4a) 1/2S d/2, (4b) 1/2S d/3 ET 2.5% .8/y and (4c) DCA system.

Table 1 Relation between estimated size of latex regeneration area, production and average metabolic parameters (Suc, Pi) measured inside latex of panel (A) of different tapping systems.

Tapping system	Latex regeneration area (m^2)	Average [Suc] concentration Panel A (mM.l.latex^{-1})	Average [Pi] concentration Panel A (mM.l.latex^{-1})	Average production (g.tree^{-1}. tapping^{-1})	Production[1/] (kg.tree^{-1}. year^{-1})
1/2S d/2	0.29	14.1	11.5	33.1	4.40
1/2S d/3 ET 2.5%	0.32 (10%)[2/]	13.6 (-4%)	11.2 (-3%)	43.7 (32%)	3.85 (-12%)
DCA[3/]	0.42 (45%)	13.1 (-5%)	19.6 (71%)	42.3 (28%)	5.62 (28%)

Remark 1/ Rubber production during May 2000 – February 2004.
2/ (-) percentage compared with control (1/2S d/2).
3/ DCA: 2×1/2S d/4(t,t) ET2.5% 2×4/y (8/y)

For panel B (untapped panel) of 1/2S d/2 and 1/2S d/3 ET 2.5%.8/y treatments, sucrose content difference were not significant. A similar result was already observed by Tupy (1973a) when he measured the sucrose content along the trunk of an untapped tree. This suggested the equilibrium of sucrose concentrations between latex cells and the surrounding phloem tissue in the case of a concurrent very low latex metabolic activity. In contrast, panel B was cut on DCA system and sucrose content was higher than other treatments.

2.3 Relation between latex sucrose content and metabolic activity

Latex sucrose content and latex Pi content of control (1/2S d/2) and 1/2S d/3. ET2.5%,8/y (Figures 5a and 5b) were negatively correlated. As the metabolic activity was higher, an increase in latex metabolic activity (higher Pi) was mainly due to the increase in the latex regeneration process, that required an increased sucrose consumption. A higher latex metabolic activity increased the sucrose consumption and latex sucrose content, therefore, decreased. The latex system mostly functions as a utilization sink.

Conversely, with DCA system (Figure 5c), latex sucrose content and latex Pi content were both negatively correlated and positively correlated. Negative correlation regarded the latex system functioning as a utilization sink. The positive correlation was as higher latex metabolic activity (higher Pi) enhanced sucrose importation into the latex cells. The latex system mostly functions as an accumulation sink.

The location of the latex regeneration bark area mostly on tapped panel (A), below and above the tapping cut, was also confirmed by the previous works of several authors using very different methods like using radio-labeled isotopes (Lustinec and Resing,1965, 1968; Lustinec *et al*.,

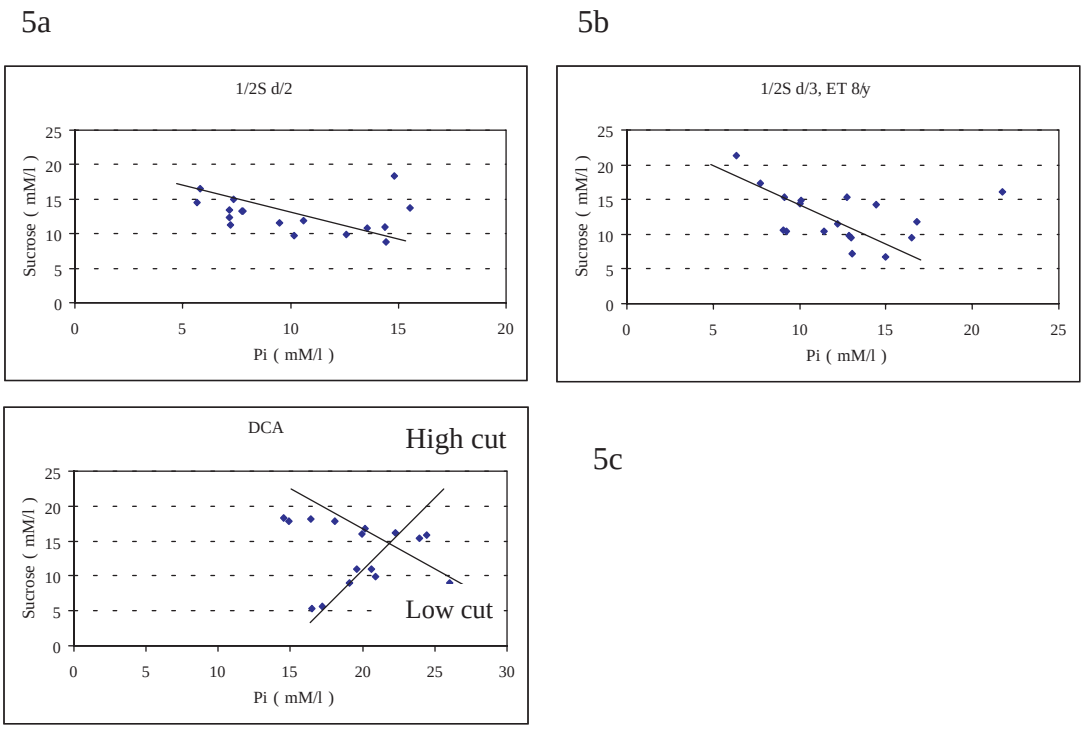


Figure 5 Relation between latex sucrose content (Suc) and latex inorganic phosphorus content (Pi): all sampling positions. (5a) 1/2S d/2, (5b) 1/2S d/3 ET 2.5% .8/y and (5c) DCA system.

1969), turgor pressure measurements (Buttery and Boatman, 1966, 1967; Pakianathan *et al*., 1975) and latex diagnosis mapping (Silpi *et al.*, 2001).

CONCLUSION

These results concerning the latex metabolic activity, based on the comparative evolution of latex sucrose content and concurrent latex inorganic phosphorus content in several areas of the trunk bark of *Hevea brasiliensis* confirmed the bark production area. According to the concurrent sucrose level, this high metabolic activity area could be divided in two distinct secondary areas:

A first area, with concurrent low sucrose and high Pi, close to the tapping cut, that could be considered as the actual latex regeneration area.

A second area, with concurrent high sucrose and high Pi, more distant to the tapping cut, that represented a highly active sucrose importation area, whose duty was still unknown (sugar reserve for next latex regeneration).

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